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AN ENDEAVOUR TO SHOW THAT INSUFFICIENCY OF THE INTERNAL RECTI MUSCLES AND MYOPIA HAVE BEEN ERRONEOUSLY ASSOCIATED; AND THAT THE MUSCULAR ASTHENOPIA OF MYOPIA IS NOT THE RESULT OF SUCH INSUFFICIENCY, BUT OF THE ANOMALY OF REFRACTION.

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EXAMINED by means of the usual tests, which are employed for the detection of insufficiency of the internal recti muscles, there are but few cases of myopia which will not furnish the conditions considered sufficient to demonstrate the existence of this affection. Hence it is that, as the accuracy of these tests has been very generally accepted, insufficiency of the internal recti muscles has come to be looked upon as the rule, rather than the exception, in myopia; a recent writer upon this subject,¹ stating that it exists in, perhaps, nine-tenths of all the cases of progressive myopia; while the same writer quotes Giraud Teulon as saying, that he regards the existence of staphyloma posticum "rather as an evidence of the insufficiency than of the myopia."

First, then, let us inquire what are the tests relied upon. There are two which are usually employed. In the first and less accurate one, the subject of the examination is directed to regard an object held in the median line at a short distance from the eyes (8'' or 10''). One eye is then excluded from vision by the hand, or by a screen placed before it, and the movement which it makes upon such exclusion is noted. If it is found to rotate outwards, while the uncovered eye continues in its former position, so that, when the hand is removed, a movement of convergence is required in order to restore binocular vision, weakness or insufficiency of the internal recti is assumed.

The second test, which is more relied upon, and is based upon the inability of the eyes to overcome vertical diplopia, was devised by Von Graefe. A black dot, with a fine line passing vertically through it, is drawn

¹ Dr. R. H. Derby, of New York, in an article upon Progressive Myopia and its Operative Cure, in the N. Y. Medical Journal, June, 1873.

upon paper, and being placed in the median line, at a distance of 8'' or 10'', the patient is directed to regard it while a prism of 10° or 12° is held, with its base directed either upwards or downwards before one eye. As the result of the action of the prism, held in this manner, vertical diplopia is produced. Two dots, one situated above the other, are seen. If the dots are found to stand in the same vertical line, the balance of power between the external and internal recti is considered to be normal. If, however, the dots exhibit a lateral as well as a vertical deviation, and if this lateral deviation is crossed—that is, if the right eye sees the dot which stands to the left, and *vice versa*, then, as this evinces relative divergence of the optic axes, the existence of insufficiency of the internal recti is considered to be established; and the weakest prism which, held before one eye, with its base inwards, corrects the lateral separation of the dots, and makes them stand one directly above the other, is considered as the index of the degree of the insufficiency for the distance at which the test is made. A candle flame is then, usually, substituted for the dot and line, and being placed 10' or 15' from the patient, the trial is repeated in order to discover if, even at that distance, insufficiency still exists.

Let us now consider the accuracy of these tests. They have been almost universally adopted; but are they, indeed, reliable? *Except in cases of emmetropia*, that is, where no anomaly of refraction exists, I unhesitatingly answer *no*. If hypermetropia be present they demonstrate an excess of power in the internal recti muscles, which is not real; whereas *in myopia they exhibit an insufficiency in these same muscles, which is only apparent*. I shall endeavour, successfully, I hope, to sustain this assertion.

There is a condition which exists alike in myopia and in hypermetropia, and which, I think, is competent to explain most of the muscular disturbances that occur in these forms of ametropia; and to explain them in accordance with a common principle, the significance of which, I am persuaded, has not been fully appreciated. That condition consists in the disturbance of the parallelism which, in the emmetropic eye, exists between accommodation and convergence.

The ciliary muscles and the internal recti receive their supply of motor nerves from a common origin, the third pair. The latter muscles have two modes of action. They may act in conjunction, producing convergence of the optic axes; or each internal rectus may, in connection with the external rectus of the opposite eye, produce the lateral movements of the eyes, which are important in enlarging the visual field. In the latter case their action is independent of the accommodation. Between the concomitant action, however, of the internal recti muscles, producing convergence, and the action of the ciliary muscles in accommodation, there exists such an interdependence, such a oneness of nervous influence, that it is impossible, except by an exhausting effort, and then only to a relatively slight

extent, for them to take place independently of each other. The same mandate of the will, which commands an effort of convergence to be made, unconsciously directs a like effort of accommodation; so that there necessarily exists a constant parallelism between the amount of work which the ciliary muscles and the internal recti, together, perform.

Thus when an emmetropic individual views distant objects, with parallel optic axes and relaxed accommodation, his convergence and accommodation are, alike, $= 0$. When he regards an object at $10''$, and converges for that distance, his accommodation $= \frac{1}{10}$; *i. e.*, his ciliary muscles have exerted sufficient force to increase the convexity of the lenses to such an extent as to augment their refractive power to an amount equivalent to the action of a lens of $10''$ focal length. If he converges for a nearer point, $3''$ or $4''$, his accommodation increases proportionately, becoming $\frac{1}{3}$ or $\frac{1}{4}$.

So long, then, as this normal parallelism maintains, convergence and accommodation may be indefinitely prolonged without effort or fatigue. When, however, this is disturbed; when the ciliary muscles are compelled to perform more work than should correspond with the work, at the same time, performed by the internal recti, or *vice versa*, a manifest effort is required, where none before was necessary; and, as a result of this, fatigue of the eyes or asthenopia is superinduced.

In myopia, and in hypermetropia exactly such disturbance of the parallelism between convergence and accommodation as this necessarily exists. In hypermetropia, in order to overcome the error of refraction, the ciliary muscles are obliged to perform more work than the internal recti. Asthenopia results, and in many cases, in order to relieve this, the internal recti are allowed to perform an amount of labour equal to that of the ciliary muscles; convergent squint being the result. To illustrate this, let us suppose a case of hypermetropia $= \frac{1}{8}$. The subject of it wishes to read at a distance of $8''$. To do this his accommodation must $= \frac{1}{4}$, while his convergence must be not for $4''$, but for $8''$. Asthenopia ensues, and will persist, unless he is willing to sacrifice binocular vision, and converge for $4''$, while his eyes are accommodated for a distance of $8''$ only.

For this explanation of the asthenopia of hypermetropia, and of the connection between hypermetropia and *convergent* strabismus, we are indebted to Donders. He does not, however, seem to have considered the same reasoning as applicable to the asthenopia and the *divergent* strabismus of myopia; but, on the contrary, he considers the latter as due, mainly, to the peculiar ovoid form of the myopic eye, and to the smallness of the angle formed by the optic axis and visual line; conditions which, for mechanical reasons, render convergence difficult;¹ while, in connection with the former, he assumes "a true insufficiency of the musculi

¹ Accommodation and Refraction of the Eye, Donders, p. 403.

recti interni." Speaking of asthenopia muscularis in connection with myopia, he says :—

"Cases have occurred to me, in which there was at first vision [in near work] with both eyes, but where, on fatigue, the one eye gave way, and the work was then attended with less difficulty; others where precisely that giving way caused trouble and was complained of. This latter state I met with when the degree of the myopia was comparatively slight, and where, therefore, besides resistance of the eye, a certain weakness of the muscles (not only insufficiency of movement, but true *insufficiency of the musculi recti interni*, must be understood); a condition which, in moderate degrees of myopia, I have found to be hereditary, with the phenomena just described."

This assumption of Donders, together with the test of Von Graefe, which I have described, are chiefly responsible for the generally adopted belief in the association of insufficiency of the internal recti muscles with myopia. To account, however, for the symptoms, which Donders has described, no such assumption is necessary. They are, indeed, exactly such as we should anticipate from the disturbed relation between convergence and accommodation, which, as I have before stated, exists in myopia as well as in hypermetropia. In hypermetropia, accommodation is in excess of convergence. When the eyes are used, especially for near work, asthenopia ensues; the ciliary muscles soon become tired and give way, and the sight grows indistinct. A convergent squint, by neutralizing the excess, may do away with these symptoms. In myopia, convergence is in excess of accommodation. Asthenopia, attended by giving way of the internal recti, is the result. As, in hypermetropia, there is no actual weakness of the ciliary muscles, so, in myopia, there is no real insufficiency of the internal recti. It is, in each case, the muscles which work in excess, that evince such signs, and, as in the former condition an effort is made to neutralize this excess by a convergent squint, so, in the latter is it accomplished by a divergent squint. There is this difference, however, between the two. In hypermetropia, as there is excessive action of the ciliary muscles, the parallelism is restored by excessive action upon the part of the internal recti; the repeated efforts of the ciliary muscles to do so, by relaxing their tension, being incompatible with useful vision. In myopia, on the contrary, as there is diminished action of the ciliary muscles, it is restored by diminished action upon the part of the internal recti; its restoration by increased action of the former being of course impossible, although, as is well known, the ciliary muscles do act unnecessarily, and even to the detriment of vision, in myopia, causing the binocular far point to lie nearer the eyes than the monocular. This view of the origin of divergent strabismus affords us a most satisfactory explanation of the fact of *relative divergent* strabismus being so much more common than *relative convergent* strabismus. In hypermetropia accommodation is *always* in excess of convergence, not only for near work, but for *distant vision* as well; therefore absolute soon follows upon relative convergent squint. In myopia, on the contrary, convergence is in excess of accommodation

during near vision only, hence relative divergent squint is much more frequently met with, in connection with myopia, than absolute. There are, however, exceptions to this rule. In the higher degrees of myopia, owing to the slight or even negative value of the angle formed by the optic axis and visual line, actual *convergence of the optic axes* becomes necessary in maintaining binocular vision even *for a distance*. Here then we have the conditions for the production of *absolute divergent strabismus*; and it is, indeed, in connection with such high degree of myopia that we find it occurring.

Let us now recur to the tests, the accuracy of which I have impugned, and in order to understand fully their significance, let us ask why a correcting squint does not occur in every case of myopia and hypermetropia, if it is possible thereby to eliminate the attending asthenopia by restoring to their normal parallelism convergence and accommodation? It is because such a squint is, in its inception, necessarily attended by diplopia or double vision; a condition which, in the majority of cases, is even more intolerable than the asthenopia which it would supplant. Eliminate this tendency to prevent diplopia, and the correcting squint at once takes place. The tests which we are considering accomplish this elimination; the first by excluding one eye from vision; the second by producing vertical diplopia, which it is impossible for the eyes to overcome, and which, owing to the character of the test object used, is generally accompanied by an indifference to lateral diplopia as well. Hence it is that I have pronounced them unreliable when myopia or hypermetropia is present. In the former condition the divergence of the optic axes which takes place when either of these tests is applied, and which has been looked upon as proof of the existence of insufficiency of the internal recti, represents, unless it exceed certain limits, merely the ever present, but for the moment unrestrained desire, to exact as little work of the internal recti as is, at the same time, required of the ciliary muscles.

The amount of this apparent insufficiency, which will vary with the degree of the myopia, and the distance at which the test objects are viewed, may be approximatively ascertained for any particular case if these and the width between the centres of the pupils be given. Thus if we assume with myopia $\frac{1}{3}$ a width of 64 mm. between the centres of the pupils, the test object to be held at 8'', accommodation would = 0; and if the parallelism be restored, convergence would also be *nil*, *i. e.*, it would be the same as for distance. We have only then to ascertain, by means of a protractor, the angle of convergence at which the visual lines would meet at 8''; which we should find to be 18° , and subtract from this the value of the angle at which they would meet after parallelism between accommodation and convergence had been restored, which in this case is practically 0, to know the degree of the apparent insufficiency 18° . Or, again, if we assume with the same interocular width, myopia $\frac{1}{2}$ the test to be for

8'', as before; accommodation would $= \frac{1}{8} - \frac{1}{12} = \frac{1}{24}$. Parallelism would be restored by convergence for 24''. The protractor shows that this would take place under an angle of 6° . Subtract this from the 18° which we have already ascertained as the angle of convergence for 8'', and we have the apparent insufficiency for this distance 12° .

Practically, however, owing to the habit which in myopia has been long acquired of compelling the internal recti to work in excess of the ciliary muscles, the value which we should thus obtain would probably be somewhat greater than we should find upon resorting to the dot and prism test. If, on the other hand, the degree of the apparent insufficiency, as shown by the test, is greater than the amount which we have ascertained by calculation, then we must assume that the difference between them represents either an actual insufficiency of the internal recti muscles, or, more probably, a difficulty of convergence of the visual lines due, as Donders has pointed out, to the peculiar conformation of the myopic eye. In proof of the foregoing the results of the following experiments which have been made with the view of substantiating the statements which I have advanced, and of proving the accuracy of Von Graefe's test, are submitted.

I am myself myopic, having in each eye myopia $\frac{1}{16}$. I find that, when regarding a candle flame 20' distant, either with or without correction of the error of refraction, I am able to overcome by a forced convergence a prism of 70° ,¹ base outwards. When regarding a vertical line at the distance of 8'' I can overcome one of 64° , and after correcting my myopia one of 70° . This would certainly seem to indicate that there is no actual insufficiency of the internal recti muscles; and yet, according to Von Graefe's test, such insufficiency does exist, because I find, at a distance of 8'', lateral crossed, as well as vertical separation of the dots. A prism of 12° , base inwards, corrects the lateral separation. If, however, I neutralize the error of refraction, which exists in my eyes, with $-\frac{1}{16}$ glasses, and then submit them to the test, the lateral separation of the dots does not take place, and there is no longer any indication of insufficiency of the interni. Why? Because I have, by this means, restored the parallelism between accommodation and convergence, the disturbance of which was the cause of the apparent insufficiency. The ciliary muscles must now, in order to overcome the effect of the concave glasses, perform an amount of work equivalent to that done by the internal recti. For a convergence of 8'' accommodation now $= \frac{1}{8}$, whereas before it amounted to $\frac{1}{16}$ only. If, instead of merely correcting the myopia, I more than neutralize

¹ This represents the combined strength of the eleven prisms which are contained in my (Nachet's) case of trial glasses. After one or two trials with several of the stronger ones combined, I was able to overcome all of them placed with their bases corresponding, and could have accomplished still more if my supply of prisms had not become exhausted.

it by substituting for $-\frac{1}{16}$, $-\frac{1}{8}$, and thus produce artificial hypermetropia, I then bring about that condition of things which exists in real hypermetropia. The ciliary muscles are compelled to perform more work than the internal recti; and now the test demonstrates an apparent excess of power in the internal recti; for there is homonymous lateral separation of the dots, showing relative convergent squint. If, instead of the concave I substitute convex glasses, then as the disproportion between accommodation and convergence is increased, a greater degree of apparent insufficiency of the interni is shown by a wider separation of the dots. When, however, I place before one eye a concave glass, which more than neutralizes the myopia, and before the other a convex glass, which serves to increase it, the most striking result is obtained. It is impossible, under such circumstances, to see both dots distinctly at the same moment. In order to see one excessive accommodation is necessary; to see the other accommodation must be completely relaxed. With excessive accommodation, that is, when the object is regarded with the eye before which the concave glass is placed, there is lateral homonymous separation of the dots; as accommodation is relaxed, so that the other eye may be able to see distinctly, the dots are seen to change their position; and, now, crossed diplopia occurs instead of homonymous. Thus, by varying the tension of accommodation, we may exhibit, at will, apparent excess of power or apparent insufficiency of the internal recti.

In a report on the progress of ophthalmology¹ by Dr. B. Joy Jeffries, of Boston, I find mention of a case of "Seeming Perversion of the Law of Concomitant Squint in Certain Forms of Anisometropia," reported by Prof. Alfred Graefe, in which a condition exactly similar to that which I have just described existed, and was attended by precisely the same result as regards the action of the internal recti muscles. Myopia existed in one eye, hypermetropia in the other. Insufficiency of the internal recti muscles was stated to be present. "The covered myopic eye converged, the covered hyperopic eye diverged." What explanation the observer gave of the facts, or what conclusion he drew from them, is not stated.

We have now to consider this condition of disturbed parallelism between accommodation and convergence in myopia in its practical, and by far its most important aspect; namely, its influence upon the progress of myopia. Although I have endeavoured to show that true insufficiency of the internal recti and myopia have been erroneously associated, I am fully in accord, though differing as to its cause, with those who look upon difficulty of convergence of the visual lines in myopia as a most important factor in the development of this condition.

The effort which attends the unsupported action, so to speak, of the internal recti in myopia, when the eyes are used for near work, is soon

¹ Transactions of the American Ophthalmological Society for 1871, page 17.

followed, as has already been pointed out, by muscular asthenopia, attended by a state of irritation, and of congestion of the bloodvessels of the eye, which is only too well suited to the development of staphyloma posticum. The investigations of Donders, of Cohn, of Erismann, and of others, all go to show that the persistent use of the eyes for near work, as in reading and writing, furnishes the conditions most favourable to the production and increase of myopia; and it is under such circumstances that the disproportion between accommodation and convergence, being greatest, is capable of exerting, in the manner indicated, the most potent influence in promoting such increase.

The tendency of myopia, except in its higher degrees, to become stationary between the thirtieth and fortieth years of life, after a stage of temporary progression, most marked during youth, has been well established, but no satisfactory explanation of the fact has been advanced. As the result of his observations Donders has stated that, "In youth almost every myopia is progressive; *the increase is then often combined with symptoms of irritation.* This is the critical period for the myopic eye; if the myopia does not increase too much it may become stationary, and may even decrease in advanced age; if it is developed in a high degree it is subsequently difficult to set bounds to it."

A moment's reflection will show us that the disturbed parallelism between convergence and accommodation in myopia will be favourably modified by the approach of presbyopia, *i. e.*, by the recession of the near point; and in such modification we have an explanation of the disappearance of the asthenopia which existed in earlier life, and of the gradual diminution and eventual arrest of the progress of the myopia itself.

The diminution of the power of accommodation, which when it has reached a certain stage constitutes presbyopia, and which commences in the earliest years of life, is the result, as Donders has pointed out, not of loss of power of the ciliary muscle, but of gradually increasing firmness of the crystalline lens; so that, though the former may be capable of exerting as much power as ever, it is incapable of producing the same amount of change in the conformation of the lens: which change is the essence of accommodation. As the result of this, it will be seen, that with the approach of presbyopia, the necessity which existed in youth of suppressing accommodation, and forcing the internal recti to work unsupported, gradually disappears, because now the effort of accommodation, which would correspond to a given effort of convergence, is attended by an amount of actual accommodation by no means equal to that which in youth would have been accomplished by it.

Thus, for example, a young person with myopia $\frac{1}{16}$ wishes to read at

¹ Op. cit. page 344. I have taken the liberty of italicizing a portion of the extract.

8". The amount of accommodation, which corresponds with the convergence, which this would necessitate $= \frac{1}{8}$. He desires, however, owing to his myopia, only $\frac{1}{16}$, and is, therefore, compelled to suppress $\frac{1}{16}$. At fifty years of age, however, the amount of actual accommodation, which he is capable of exercising, is reduced to $\frac{1}{16}$, and he, therefore, requires the whole of it in order to enable him to see distinctly at 8". There has been, from youth up, a gradual diminution of the amount which it was necessary for him to suppress, until now there is none remaining; and the parallelism between the *effort* of convergence and the *effort* of accommodation is at last complete. But, indeed, for the influence of the myopia, we would be presbyopic, and would require, in order to read at 8", convex $\frac{1}{16}$ spectacles. The myopia serves the purpose of the convex glasses however, and presbyopia is, for a time, deferred.

If it be true that the disproportion between accommodation and convergence in myopia is capable, in the earlier years of life especially, of exerting so potent an influence in promoting its increase, it becomes important that in the treatment of progressive myopia our attention should be directed towards it, as a condition the elimination of which is of the greatest moment. Let us inquire in what way this elimination may be accomplished.

As, under such circumstances, convergence is in excess of accommodation, it is evident that, either by diminishing the extent of the former, while the latter remains constant, or by increasing the latter while the former is unchanged, equality between them may be restored. By means of prismatic glasses, we have it in our power to diminish the convergence to any desired extent; or we may increase accommodation and make it equal convergence by neutralizing the myopia by concave glasses. Practically, however, the latter plan is not available except in the slighter degrees of myopia; because the tension of accommodation which it necessitates is itself found to be productive of mischief. "When the myopia is slight in reference to the range of accommodation, and the eye is otherwise healthy," we may, nevertheless, resort to this method of correcting the disproportion, and thereby relieve the asthenopia, and favourably modify the progress of the myopia. We have the authority of Donders for saying that under such circumstances "neutralizing glasses may be worn as spectacles, and may be used even in reading and writing." "I think it is even desirable," he adds, "that this should be done. When persons with moderate degrees of myopia have in youth accustomed themselves to the use of neutralizing spectacles, the eyes are in all respects similar to emmetropic eyes, and the myopia is, under such circumstances, remarkably little progressive." "I am acquainted with numerous examples of this even among those of my friends who have passed their lives in study."¹ And, again, in speaking of insufficiency of the internal recti

¹ Op. cit. page 421.

muscles in myopia he says, "The insufficiency first makes itself known by asthenopia muscularis in binocular vision for near objects. Sometimes we find (at least temporarily) the proper remedy for this state of things in concave glasses, which bring r^a [the furthest point of binocular distinct vision] to from 12" to 14", and we may try these if there is no contra-indication for other reasons against them."¹

These statements may be looked upon, I think, as decidedly favourable to the position which I have endeavoured to establish, not only as regards the cause of the muscular asthenopia, but as regards the benefit to be derived from the elimination of this cause in correcting the asthenopia and in favourably modifying the development of the myopia.

It is, however, from the careful application of prismatic glasses, to be worn whenever the eyes are used for near work, the strength of the prisms to vary, as a rule, with the degree of the myopia, and the distance at which the work is to be done, whereby we are enabled to neutralize the excess of convergence over accommodation; or, where the myopia has reached such a degree that the far point lies nearer than 8° or 10° from the combination of concave and prismatic glasses, that we shall be able to derive the greatest benefit in our treatment of progressive myopia.

This plan of treatment, indeed, is that from which Von Graefe obtained most satisfactory results in the management of myopia, in connection with which he had proved, in accordance with his method (the fallibility of which, under such circumstances, has, I think, been clearly established), the existence of insufficiency of the internal recti. That it has not been more generally adopted, and that it has not been attended with that degree of success which its rationality would seem to bespeak for it, is not the result, I believe, of any defect in the method itself, but of its applicability having been based upon incorrect grounds, which, of course, rendered the construction of correct rules for its application impossible.

Our starting-point in the formation of such rules should be the restoration of parallelism between convergence and accommodation; but, as in hypermetropia, its complete restoration by entire correction of the error of refraction by convex glasses, though theoretically the proper remedy, is not to be thought of so long as accommodation remains active; so, in myopia, its complete restoration by means of prisms, though equally correct in theory, would be quite as erroneous in practice. As prismatic glasses have been resorted to heretofore in the treatment of myopia upon the theory of the existence of insufficiency of the interni, which it was considered desirable should be completely corrected, the error, I think, has been made of prescribing those of too great strength; which, proving on this account irksome and productive less of comfort than of discomfort, have been forthwith thrown aside.

¹ Op. cit. page 426.

In determining the strength of the prisms which are required in any given case, we should first ascertain the degree of the myopia, and then the character of the near work at which the eyes are usually employed, so that we may know for what distance the correction is to be made. If the myopia is found to be so great as to require the work to be performed nearer the eyes than would be otherwise desirable, we should, by combining a concave surface with the prism, remove the binocular far point to the desired distance; and we must, then, in our calculations, consider only the myopia which remains uncorrected. We should next ascertain the width between the centres of the pupils (which may be readily done, with sufficient accuracy, by means of an ordinary tape measure, or rule, held across the bridge of the nose, the patient being directed, in the mean time, to regard some distant object so that the optic axes may be parallel); and, having learned this, we may now find by calculation, in the manner before described, the actual excess of convergence over accommodation for the distance which we have selected.

This calculation, though not absolutely necessary in practice, is desirable because, as has already been pointed out, if the disproportion, thus obtained is found to be less than the apparent insufficiency shown by Von Graefe's test, it shows that besides the refractive anomaly, there are other causes tending to produce difficulty of convergence; and this knowledge would justify us in prescribing stronger prisms than we should otherwise do. By constructing a reference table which would show the disproportion proper to the different grades of myopia at the usual working distance, say 10° , with a maximum, medium, and minimum interocular width, we may save ourselves the trouble of making the calculation in each individual case.

Most important, however, is it for our purpose, to carefully ascertain, by means of Von Graefe's test, the *apparent* insufficiency of the internal recti, at the distance for which it is proposed to make the correction; because it is mainly upon the result of this that our determination in regard to the strength of the prisms to be selected must depend. We should, moreover, not neglect to repeat this test after neutralization of the myopia by concave glasses; under which circumstances, if we are careful to observe that the patient accommodates accurately for the distance at which the test object is held, which he may be inclined not to do on account of the unusual effort required to overcome the action of the glasses, we shall generally find that all indications of insufficiency have disappeared. If, however, crossed diplopia still persists, and we are satisfied that accommodation is being properly directed, we must conclude that there is either true insufficiency of the internal recti or difficulty of convergence, such as has been already referred to.

And here I would suggest the advantage of substituting for the dot either a small cross or a star, as it will be found easier to accommodate accurately for them, owing to their more striking outlines. The line

should, I think, be entirely omitted, as it is in reality of but little advantage; and, on the other hand, it may, as I have found from my own experience, greatly interfere with the accuracy of the result. The cross combines, in a measure, the advantage of the dot and line without the disadvantage of the latter; if astigmatism happened, however, to be present, it might be productive of some confusion as regards accommodation.

What proportion of the apparent insufficiency it is allowable, as a rule, to correct, I am not prepared to state. Experience alone can determine this point, and of this I have not had sufficient to justify me in expressing an opinion. With the approach of presbyopia the total value of this apparent insufficiency should diminish; and, therefore, we may conclude that with advancing age, other things being equal, the strength of the prisms required would be less; a rule exactly the opposite, and for reasons which are manifest from what has gone before, to that which maintains in the correction of hypermetropia.

For myself I find very decided comfort when compelled to use my eyes persistently for near work, as in reading or writing, from the use of prisms of 2° , the bases, of course, turned inwards. As I have, with myopia $\frac{1}{16}$, an interocular width of 64 mm., the difference between the convergence which is necessary for binocular vision at 10" (about the usual distance for reading) and that which would correspond to the amount of accommodation which I exercise at that distance ($\frac{1}{26\frac{2}{3}}$) amounts to $8\frac{1}{2}^\circ$. A prism of 12° corrects the lateral deviation of the dots at the same distance when Von Graefe's test is applied. It must be borne in mind, however, that by a prism of 12° is meant one whose angle of refraction is 12° , and that it does not refer to the angle of declination. Its angle of declination, in the position in which it would be held in making the test, would be somewhat more than half of its angle of refraction. From which we see that the apparent insufficiency, as we should expect, amounts to about 2° less than the actual disproportion obtained by calculation; and that the prisms which, practically, are found to be of most benefit correct only about one-third of this; those which neutralize the whole of it being quite intolerable.

The objection which has been urged against the use of prisms in muscular asthenopia, that the weakness of the muscles would thereby be increased, evidently does not apply to their use in the asthenopia of myopia, because, as we have endeavoured to show, this is not the result of muscular weakness. Of course, as in the use of convex glasses in hypermetropia, after the habit of wearing them has become established the need of them will be more felt; but, on the other hand, we have the prospect, unless the degree of the myopia be high, of being able to cast them aside altogether upon the approach of presbyopia.

I should not omit to mention, moreover, the advantage which may be derived from an eccentric position of the ordinary concave glasses, whereby a degree of prismatic action is obtained. In the higher grades of myopia

where concave glasses are necessary, even for near work, we may, by increasing the distance between the glasses, so that each eye shall look through the inner half of the glass, obtain an effect similar to that which would be produced by the combination of a prism, base inwards, with a concave glass; and if the lenses needed for such correction are of considerable strength, the prismatic effect which we can thus obtain may be sufficient for our purposes. We may, also, correct in this manner very satisfactorily that slighter excess of convergence over accommodation, which, as I have pointed out, may, under such circumstances, exist even for distant vision. In the slighter degrees, also, where total correction for near work may not prove acceptable, we may, by a partial correction and an eccentric position of the glasses, restore parallelism between convergence and accommodation and obtain very satisfactory results.

And here I would direct attention to the ill effects of a habit, which is only too common—that of wearing nose-glasses, for the correction of myopia for distant vision, the centres of which are often much nearer together than the centres of the pupils. As the result of this we have prismatic action the opposite of that just described, and necessitating, in order to overcome the diplopia which would otherwise result, a certain amount of convergence of the optic axes even for distant vision, with which an accommodation movement is associated, whereby the short-sightedness is not only temporarily increased but the progress of the myopia promoted. Though attention has been directed to this point before, it does not seem to have received the consideration which it deserves on account of its practical importance.

The division of the external recti muscles in muscular asthenopia in connection with progressive myopia, which has been recommended as a means of arresting the increase of the latter, is an extreme measure which, even where real insufficiency exists, it seems to me should be rarely resorted to, because, in most cases, the benefit to be derived from the operation may be obtained in a more satisfactory manner by the use of prisms; and where the insufficiency is the result of the anomaly of refraction, and, therefore, is only apparent, it is certainly not to be thought of.

BALTIMORE, NOV. 1, 1873.

